Contributions to Western Australian orchidology: 1. History of early collections, taxonomic concepts and key to genera

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"I observe that Dr Lindley considers both my single-flowered Drakeas as identical, and calls the species *elastica*; but they are perfectly distinct. I have named them *D. livida* and *D. lucida*, and can discriminate them at first sight, and as far off as the plants are discernible, with unfailing certainty, when in the growing state, though even I am puzzled to detect the difference when they are dried."

Drummond (1842: 628)

"To include a great number of very distinct varieties under one species cannot, if it be possible to avoid it, be satisfactory."

Fitzgerald (1882)

Abstract

Hopper, S.D. & Brown, A.P. Contributions to Western Australian orchidology: 1. History of early collections, taxonomic concepts and key to genera. *Nuytsia* 14 (1): 1–26 (2001). This paper provides a general introduction to a series on the taxonomy of south-western Australian orchids, as well as a new key to genera from this region. The series is based on extensive field and herbarium studies completed over the past two decades. It focuses on *Caladenia* R. Br., *Drakaea* Lindl. and allied genera which have many previously unresolved polymorphic species complexes of the kind alluded to by Drummond and Fitzgerald in the above quotations.

Conducted in collaboration with members of the Western Australian Native Orchid Study and Conservation Group, the series is a contribution towards the bicentennial celebration of Archibald Menzies' pioneering collections of Western Australian orchids in 1791. The series will describe several taxa considered threatened, and validate manuscript names used in the second edition of Hoffman & Brown's "Orchids of South-West Australia".

In addition to conventional examination of herbarium specimens, new techniques for documenting population variation in living material have greatly facilitated the resolution of geographically and ecologically variable species complexes. These techniques include placing fresh dismembered floral

parts on system cards beneath clear magic tape, field tests for pollinator specificity, and the extensive use of 35 mm colour slides and line drawings of fresh flowers. We have also benefited from access to recently acquired data on allozyme and DNA markers.

The early history of the systematics of south-western Australian orchids is reviewed here. It comprised two phases: (1) the first encounters by Europeans and (2) the early colonial phase in which James Drummond was prominent. The strong reliance of taxonomists on the collections and observations of interested resident orchid enthusiasts is a recurrent feature of this history.

Our taxonomic concepts for genera, species, subspecies and hybrids are described. New taxa are considered to be species if they grow in populations (i.e. are not aberrant individuals within normal populations), if they have features or a combination of features not seen in any previously named species, and especially if they grow with previously named species and produce few or no natural hybrids. Geographical races with minor morphological differences are recognized as subspecies. These may hybridize and intergrade extensively where their geographical ranges overlap. Our emphasis on biological as well as morphological attributes in recognizing species and subspecies is a significant change from past practice. It leads to the recognition of more species within complexes previously treated as single polymorphic species (e.g. *Caladenia filamentosa* R. Br., *C. huegelii* H.G. Reichb.). There are many practical advantages to our approach, including improved management for conservation, improved cultivation, and more precise communication and conduct of popular and scientific studies on south-western orchids. New genera, published elsewhere, are based on numerical analyses of morphological data, as well as the recently completed DNA sequence studies of Kores *et al.* (2000, 2001).

Introduction

Two centuries ago, Archibald Menzies, surgeon and naturalist aboard the *H.M.S. Discovery,* was the first European to make collections of Western Australian orchids. The *Discovery*, under the command of Captain George Vancouver, was anchored in King George Sound from 28 September to 11 October 1791.

Menzies made a "copious collection of ... vegetable productions, principally the genus *Banksia*, which are here very numerous" from various sites onshore in the vicinity of present-day Albany (Maiden 1909; Heberle, undated). Three orchid species were subsequently named from Menzies' specimens, including one bearing his name – *Leptoceras menziesii* (R. Br.) Lindl., *Caladenia flava* R. Br. and *Diuris longifolia* R. Br. (Brown 1810; Lindley 1830–1840). The present series of publications, based on more than two decades' research, contributes towards the celebration of the bicentenary of Menzies' pioneering collections. Here, we provide a general introduction to the series, and a new key to genera of south-western Australian orchids.

South-western Australia is one of the few regions in the world where the abundance and diversity of terrestrial orchids may be breathtaking (Hoffman & Brown 1992, 1998). In some habitats, particularly the first spring after a fire, more than 40 species have been recorded in a few hectares, in some cases so abundant that walking without treading on them was impossible. But such situations are exceptional. Indeed, most residents and tourists, professional botanists among them, overlook orchids and underestimate the rich diversity found in the south-west. There are several reasons for this.

It takes many years' field experience before proficiency is developed in locating the best orchid haunts, and it takes longer to ensure seeing all of the rarest taxa. For example, even within Kings Park, located in the heart of Perth city, the orchid list continues to grow, from 28 species a decade ago (Bennett 1988) to 49 species seven years later (Hopper & Brown 1995) and 52 species by 1999. Some genera have small inconspicuous flowers that are easily overlooked in the riot of colour proffered in spring by the larger perennial vegetation. Some orchids rarely flower at all except after fire at the appropriate time and intensity. Cryptic flowering reaches its zenith in the south-west with the Underground Orchid, *Rhizanthella gardneri* R. Rogers, an epiparasite whose elusive subterranean inflorescences take an average of nine person-hours to locate within known sites (Dixon & Pate 1984; Dixon *et al.* 1990).

Some groups of orchids display a bewildering array of variation in floral morphology. Rapid geographical or ecological replacement of closely related variants occurs, comparable to that seen in *Eucalyptus* (Brooker & Kleinig 1990; Brooker & Hopper 1991), *Acacia* (Maslin 1975), *Verticordia* (George 1991), *Drosera* (Lowrie 1987, 1989, 1998), *Conostylis* (Hopper *et al.* 1987) and other species-rich genera in the south-west.

Unfortunately, until the recent publication of Hoffman & Brown (1992, 1998), the available field guides to south-western orchids (Pelloe 1930; Erickson 1965; Hoffman & Brown 1984) provided useful information only on the relatively invariant taxa. They were of little help in understanding and placing names on the plethora of variants encountered throughout the region for species complexes such as those typified by *Caladenia filamentosa* R. Br., *C. patersonii* R. Br., *C. huegelii* H.G. Reichb., *Pterostylis nana* R. Br. or *Diuris longifolia* R. Br.

Given these challenges to the most adept field botanists, and the paucity of professionals resident in Western Australia, it is perhaps not surprising that many recent discoveries of south-western orchids have been made. A wealth of new taxa continues to be identified each year as the results of detailed studies of species complexes come to hand. Just as Jones (1991: 1) remarked that, in relation to his major contribution on eastern Australian Orchidaceae, "to those associated with this research and familiar with complex groups within the Australian Orchidaceae, the description of more than one hundred new species in this paper will come as no surprise", a similar situation prevails in south-western Australia. Much more still needs to be done on the region's orchid flora before a full understanding of the taxa present can be achieved.

Two key elements have contributed to the current advances in south-western orchid systematics. Firstly, over the past two decades, the Western Australian Native Orchid Study and Conservation Group has developed and flourished as a training ground for an increasing number of skilled orchid enthusiasts and photographers. A useful dispersion of country members intimately familiar with the orchids of their districts has facilitated the location and identification of many undescribed taxa. Close involvement of professional orchid taxonomists with the Group, commencing with A.S. George and continuing with ourselves, D.L. Jones, M.A. Clements and R. Bates, has led to a productive and more rapid advance in formal systematic research than would otherwise have been possible. The rise over this same period of the Australian Orchid Foundation, a private funding agency dedicated to promoting the cultivation and scientific study of orchids, has further facilitated this interaction between orchid enthusiasts and professional researchers (e.g. Clements & George undated).

And secondly, new approaches to studying variation in orchid populations have substantially overcome taxonomic problems in dealing only with conventional herbarium specimens. Much of the structural detail, colour and odour of south-western orchids is so distorted by pressing and drying specimens that many taxonomic characters are lost to the herbarium botanist (see Crisp 1993 for a

similar example in the pea genus *Sphaerolobium*). Additionally, observations on habitat, population variation, flowering phenology and pollination are also commonly scant or absent on herbarium specimen labels.

Botanists in Britain and Europe in the 1800s had only a small number of poorly preserved herbarium specimens to work with when they commenced naming south-western orchids. This has meant that much of our current nomenclature is based on broad species concepts developed by taxonomists trying to make the best judgements they could on the limited characters detectable from the available material. Drummond (1842) was the first to allude to the resultant frustration felt by resident field botanists who could readily discern distinct species that were lumped under the one name by botanists from afar (see opening quotation).

The most striking example of such a broad species concept was Bentham's (1873: 381–382) notion that all taxa in the *Caladenia patersonii, C. longicauda* Lindl., *C. dilatata* R. Br. and *C. huegelii* complexes belonged to the one species, *C. patersonii*. Bentham commented in support of this view that *C. patersonii* was:

> "Very variable in the length and proportions of the sepals, in the shape of the labellum and its fringes and calli, and in the colour of the flowers, which are usually of a pale greenish hue outside and yellowish or pink inside, the calli and end or middle lobe of the labellum usually and sometimes the whole disk of a rich purple. The following are the principal forms this species assumes, regarded by Lindley and others as distinct species, but passing too gradually into each other to be clearly marked out from dried specimens."

He then went on to recognize the *Caladenia dilatata* complex as a variety distinct from the rest of *C. patersonii*.

James Drummond, Western Australia's first resident European field botanist, collected and separately numbered several of the new species named in the present series, and even described and named some himself in published letters to Hooker (Drummond 1842), only to see some of his observations ignored and specimens lumped under the broad species concepts of the botanists to whom they were shipped.

Bentham's (1873) and particularly Reichenbach's (1871) broad concepts were also recognized as unworkable by Australia's first resident orchidologist, R.D. Fitzgerald. Having seen and accurately painted fresh flowers of many taxa in New South Wales and some from Western Australia, Fitzgerald (1882) remarked rather caustically:

> "Specimens that, if submitted a few years ago to the highest authorities, would without doubt have been considered as representing new species, are now matters of hesitation, uncertainty, and re-comparison, and are finally pronounced to be varieties, very often to the disgust of the collector, who has seen them in a fresh state, and who cannot accept the ruling that they are identical with others previously named, with which he may be equally familiar, and into which he feels confident they never lapse."

Thus, Fitzgerald (1882) recognized *Caladenia patersonii* and *C. dilatata* as distinct species, a view that has been accepted by all authors subsequently. What has happened since has been a growing

recognition that there is also remarkable variation within species complexes such as those typified by *C. patersonii, C. filamentosa, C. dilatata* and *C. huegelii.*

Taxonomists in the first half of the 1900s began to tease apart this variation, slowly at first, with the recognition of new species and varieties by Domin (1912), Rogers (1909, 1920, 1923, 1927a, 1927b, 1938), Coleman (1930), Nicholls (1947, 1949, 1950) and others. Because much of the work of these authors was done without reference to the type specimens used by their British and European predecessors, some confusion and redescription of previously named taxa resulted. George (1971a), and more recently Clements (1989), Jones (1991) and ourselves (present series), have clarified most of the resultant nomenclatural problems relevant to south-western orchids.

Most modern Australian authors over the past two decades have achieved a thorough understanding of some orchid species complexes through the application of techniques additional to conventional study of herbarium specimens (e.g. George 1984; Jones & Clements 1987, 1989; Bates 1989; Clements 1989; Carr 1986, 1988; 1991; Jones 1991, 1998). These techniques include:

- observation of populations of living plants of taxa in the wild, and recording details of their odour, colour, and three dimensional structure, as well as noting features of the landform, soil, associated vegetation, fire response, phenology and pollinator activity - field studies have become far more comprehensive in recent decades with an improved road system and the ready availability of four-wheel-drive vehicles;

- tests of pollinator specificity by choice experiments using bait flowers of different taxa (Stoutamire 1974, 1975, 1981, 1983; Bower 1992, 1995, 1996);

- preserving flowers and leaves from each sampled population by dismembering, flattening and separately mounting in rows the petals, sepals, labellums and columns beneath clear magic tape on a system card; this procedure results in minimal shrinkage and loss of colour, exposes structure like calli for ready examination, and enables easy measurement of variation within and between populations (Figure 1);

- taking 35 mm colour slides of representative flowers of each population sampled;

- illustrating representative specimens of each taxon from fresh material;

- growing plants in cultivation to study their phenology and morphology under greenhouse conditions;

- testing taxonomic concepts through the analysis of genetic data sets using allozyme markers, DNA sequences etc. (e.g. Figure 2).

In the present study we have used these techniques, together with examination of relevant specimens in the major Australian herbaria, as well as types (or high quality photos of them) from three European herbaria (BM, K and W).

System card collections of floral parts have been particularly useful in helping to resolve geographically and ecologically variable complexes. This technique has potential for systematic studies of any plants with delicate floral parts prone to withering on conventional pressing and drying (e.g. fringe lilies (*Thysanotus*), triggerplants (*Stylidium*), sundews (*Drosera*) and peas). We are indebted to David Jones of the Australian National Botanic Gardens for introducing the technique to us.

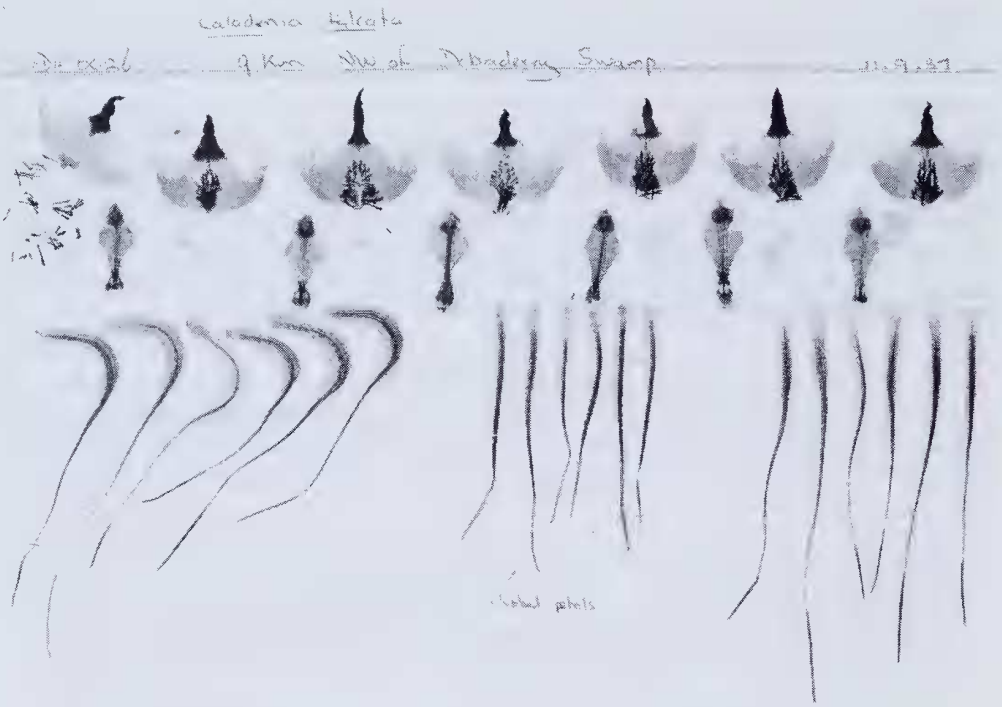

Figure 1. System card showing dissected specimens of *Caladenia falcata*.

In this series and a previous paper (Hopper & Brown 2000), we concentrate on new and reinstated south-western taxa in *Caladenia* R. Br., *Drakaea* Lindl. and allied genera. David Jones and Mark Clements have described and will be describing many new taxa of south-western *Pterostylis* R. Br., *Diuris* Sm., *Cyrtostylis* R. Br., *Gastrodia* R. Br. and *Corybas* Salisbury (e.g. Jones & Clements 1987; Clements 1989; Jones 1991). In South Australia, Robert Bates is currently working on *Prasophyllum* R. Br. and *Microtis* R. Br. (e.g. Bates 1984, 1989, 1990), while work begun by the late Joe Weber of the State Herbarium, Adelaide on *Thelymitra* Forster is now being continued by Jeff Jeanes. We would expect the description of many new taxa in these genera when further detailed population studies are undertaken.

It is timely to describe the new taxa for several reasons. Many are rare, and their formal description will aid conservation agencies in identifying and managing the few populations known (Hopper *et al.* 1990; Brown *et al.* 1998). Our taxonomic research is ongoing, but many undescribed taxa were identified some years ago (e.g. Hoffman & Brown 1984) and are well known among local orchid enthusiasts. Publication of the names will facilitate communication and increase awareness of the real wealth of orchids occurring in the south-west. And finally, the names will be validated following their informal mention in the revised editions of "Orchids of South-West Australia" (Hoffman & Brown 1992, 1998).

While we regard the descriptions in the other papers of this series as a significant new contribution to knowledge of the south-western genera treated, it is by no means the last word on the subject. As our taxonomic research is ongoing, we would welcome hearing from anyone who has found orchids that do not match those illustrated and described in this series or in Hoffman & Brown (1992, 1998).

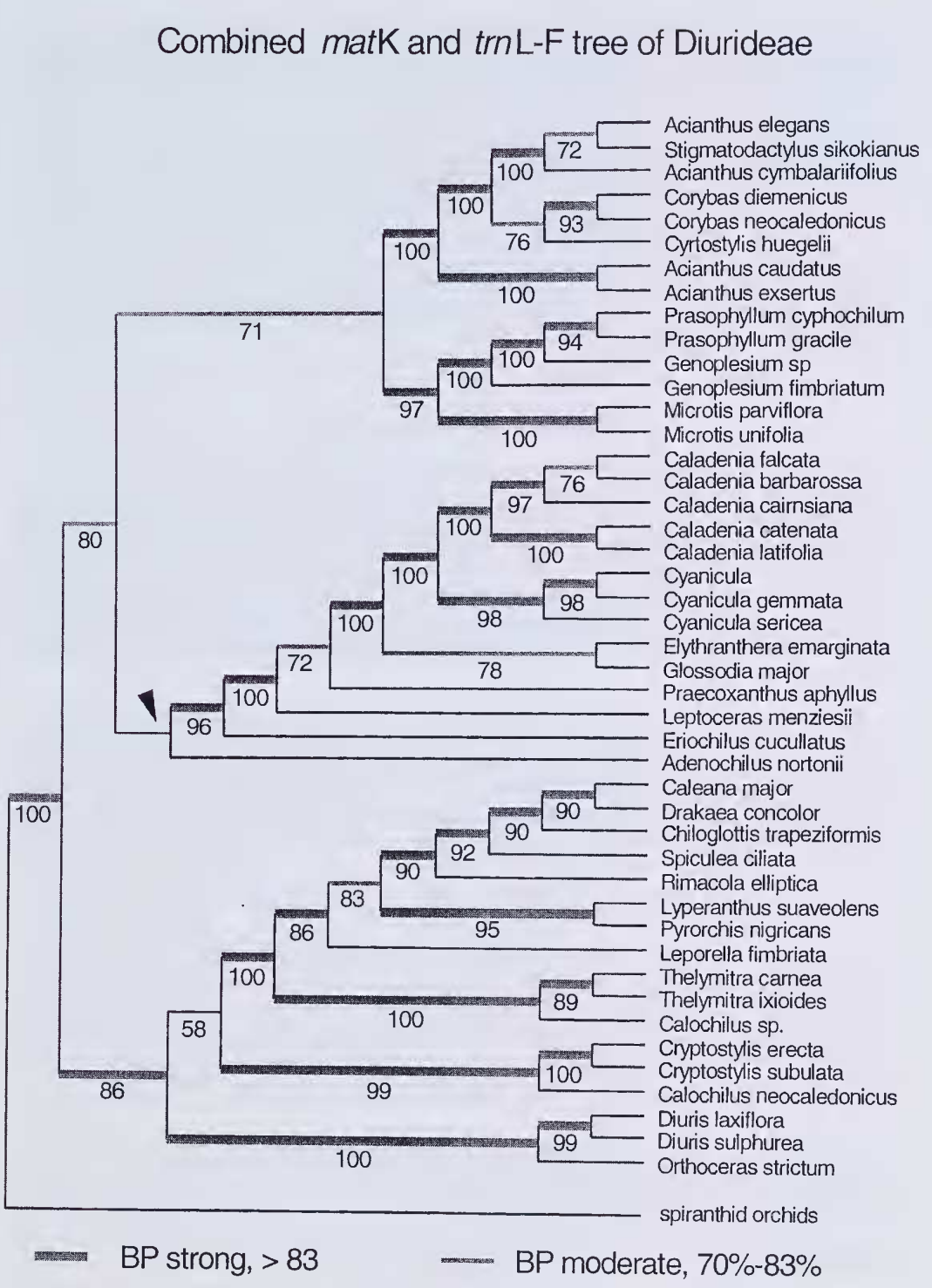

Figure 2. Evolutionary relationships of the Orchidaceae, based on DNA sequence data of three genes (Kores *et al.* 2001). Numbers of nodes are bootstrap values, with 100 meaning 100% confirmation of the node over 100 replicates.

Finally, the current surge in taxonomic research and description of Australian orchids is not without its critics (e.g. Heberle 1995; Dockrill 1995 – see Bower 1995 for an independent response). This is not unexpected, and indeed, is healthy for any area of scientific research. As long as criticism is based on careful testing and well documented falsification of taxonomic hypotheses, significant improvements in our knowledge of Australian orchids will occur. Indeed, such an approach led Bates and Weber (Weber & Bates 1978, 1986; Bates & Weber 1990) to move from early unworkably broad species concepts to a taxonomy much more in tune with biological reality. There will never be a final word on matters such as taxonomic rank and species concepts. The important advances nevertheless will occur primarily when new contributions to existing data are made by careful well-documented study. We would cite the exciting new insights gained on the evolution and classification of all organisms through the recent application of DNA sequence analysis as an especially significant example of a major advance in knowledge (see below).

Systematic history – the pioneers

Given the bicentennial celebration to which this paper is dedicated, it is fitting to review the early history of the systematic description of the south-west Australian orchid flora, focussing on the genera treated herein. We have drawn our information from several sources, the main ones being Diels (1906), Maiden (1908, 1909, 1921), Erickson (1969), Hall (1978, 1984), Carr & Carr (1981a, b), Marchant (1982), Heberle (undated), Short (1990), Barker & Barker (1990), and transcripts of James Drummond's letters to Hooker held at the Western Australian Herbarium. We have also examined specimens in the major Australian herbaria and at Kew, the British Museum and Vienna to obtain additional information on collectors.

At the outset, we wish to stress Barker & Barker's (1990) thesis that throughout the history summarised below, right to the present day, knowledge of the real contribution of all involved in the collection and naming of Australian plants, orchids included, is imperfectly recorded. Proper acknowledgment of assistance is very much a personal matter. Botanists from all ages have varied greatly in their ability and willingness to record their debt to other people. Along with Barker & Barker (1990), we have attempted to recount details of the efforts of poorly known enthusiasts as much as those of the well known botanists whose contributions rightfully have been extolled in the literature.

Four main overlapping phases may be recognized in the collection and description of south-western orchids by Europeans and their Australian descendants – (1) first encounters, (2) early colonial, (3) eastern Australian taxonomists, and (4) resident Western Australian taxonomists. Here we review only the first two of these phases, both mainly involving description of orchids by European botanists, with the most notable feature of the second phase being the outstanding contributions made by James Drummond in the 1830s. It is hoped to review subsequent phases in a future publication.

Because so little has been recorded, we have not attempted to describe aboriginal knowledge, but it must have been prodigious given the 40 000+ years of their occupation of the south-west, and the importance of some orchid tuberoids as dietary items.

First encounters

Orchids may have been seen, but were not collected, when Willem de Vlaming briefly landed on Rottnest Island and the adjacent mainland (now suburban Perth) in December 1696 and January 1697 (Playford 1998). Similarly, the fragmentary collections available from William Dampier's exploration

of Shark Bay and its islands in August 1699 do not include *Eriochilus dilatatus* Lindl. subsp. *dilatatus* and *Pyrorchis nigricans* (R. Br.) D.L. Jones & M.A. Clem. (George 1971b; Burbidge & George 1978; Keighery 1990).

As already highlighted, the first recorded collection of orchids from Western Australia was that attributed to Archibald Menzies in 1791 on the south coast at King George Sound. Menzies or his party collected the types of *Caladenia flava, Diuris longifolia* and *Leptoceras menziesii* .

The first genus of orchids occurring in Western Australia to be named by Europeans was *Thelymitra* (Forster & Forster 1776). A New Zealand collection of *T. longifolia* Forster made by the Forsters on Captain Cook's voyage of 1773 was used to establish the genus (Johns & Molloy 1983). Similarly, Smith (1798) named the genus *Diuris* from specimens of *D. aurea* Sm. collected at Sydney. The occurrence of *Thelymitra* and *Diuris* in Western Australia were to be brought to the attention of the scientific world shortly by the first major taxonomist to treat Australian orchids, Robert Brown.

The expedition to circumnavigate Australia led by Matthew Flinders in the *Investigator* anchored at King George Sound on 8 December 1801. On board as naturalist was a young Scot, Robert Brown, appointed under the patronage of Sir Joseph Banks. Also in the party were the gardener Peter Good, as conservator, and the artist Ferdinand Bauer. A full month (to 5 January 1802) was spent in the Sound, affording Brown, Good and others ample opportunity to explore and collect plants from a range of habitats around Albany. Between 10 and 18 January, the expedition also explored and collected near Esperance, landing at Lucky Bay (in the present-day Cape Le Grand National Park) for five days, and on islands in the Recherche Archipelago.

Brown and his colleagues were late in the orchid season, but collected 13 species of south-western orchids, all subsequently named by Brown (1810). Their thoroughness was reflected in the fact that only an additional four species have since been found flowering in December in the vicinity of Albany (Heberle undated). None of the 13 species collected in 1802 is in *Caladenia*, *Drakaea* Lindl. or allied genera. Undoubtedly, this would have been different had the expedition landed in spring rather than early summer.

Brown's contribution to the systematics of Western Australian orchids was far more substantial than making and describing collections of his own and colleagues. In addition, in his pioneering "Prodromus Florae Novae Hollandiae et Insulae Van-Diemen" (Brown 1810), he established 12 of the genera now known in Western Australia – *Caladenia*, *Calochilus* R. Br., *Cryptostylis* R. Br., *Cyrtostylis*, *Epiblema* R. Br., *Eriochilus* R. Br., *Gastrodia, Genoplesium* R. Br., *Lyperanthus* R. Br., *Microtis, Prasophyllum* and *Pterostylis*. Brown also named *Caladenia* section *Leptoceras* R. Br. which was subsequently elevated to generic rank by Lindley (1830–1840), and *Caleana* R. Br., recently split with its segregate genus *Paracaleana* Blaxell occurring in the south-west (Blaxell 1972).

The three species mentioned in the opening paragraph of the present paper that were collected from King George Sound by Menzies were named by Brown (1810), including the first Western Australian *Caladenia* (*C. flava*). Several additional species named by Brown (1810) from material collected in south-eastern Australia have since been found in Western Australia, such as *Pyrorchis nigricans* (R. Br.) D.L. Jones & M.A. Clem., *Caladenia latifolia* R. Br., *Cyanicula caerulea* (R. Br.) Hopper & A.P. Br., and *C. deformis* (R. Br.) Hopper & A.P. Br.

Interestingly, French botanists before and immediately after Brown's visit failed to collect orchids from the south-west coastline, mainly because of the timing of their explorations. Botanist Jacques

Julien de la Billardiere, and doctor and botanist Charles Riche with D'Entrecasteaux's expedition collected plants near Esperance from 13–20 December 1792, including the first kangaroo paw which Labillardiere subsequently named *Anigozanthos rufus* Labill. On 15 December Riche became lost inland from Dempster Head, and the next day had to abandon the plant specimens he collected in his urgency to get back to the coast and his ship (Marchant 1982). Late-flowering orchids may have been among these, but there is no record to inform us.

And on the west coast, botanists Andre Michaud, Leschenault de La Tour, and Jacques Delisse, head gardener Anselme Riedle, and gardener's boys Antoine Guichenot and Antoine Sautier with the Baudin expeditions (May–September 1801; February–March 1803), and Quoy, Gaimard and C. Gaudichaud with the Freycinet expedition (1818) all similarly did not make orchid collections that survived to be studied by taxonomists.

The genus *Corybas* was first described by Salisbury (1807) on the basis of material of *C. aconitiflorus* Salisbury from Sydney. Another 66 years would elapse before the occurrence of this genus in Western Australia was recorded by Bentham (1873).

Another famous botanical explorer, Allan Cunningham, as a member of Phillip Parker King's Australian coastal survey expeditions, appears not to have included orchids among his collections made on Middle Island on January 16, 1818, and at King George Sound during 20–31 January, 1818 and from 24 December 1821 to 5 January 1822 (Curry & Maslin 1990). Again, his visits occurred well after the main peak of flowering for orchids.

Similarly, the horticultural collector William Baxter worked in the vicinity of King George's Sound, Lucky Bay and Cape Arid in the years 1823–1825, and in 1829 (Maiden 1909). Little is known of his activities, and no orchid specimens of his are known. In a letter from King George Sound dated March 25, 1829 to Sydney's Colonial Botanist Fraser, Baxter remarked "Specimens: I have not got any worth sending, this being the worst time in all the year for them, but if we remain here until the spring I will get a rare collection." Unfortunately, Baxter sailed to Sydney in July, and missed the spring with its flush of flowering orchids (Maiden 1909).

Thus, prior to the establishment of the Swan River Colony in 1829, only 16 species of orchids had been collected in the south-west, all from King George Sound, and the majority late-flowering. In addition, 17 genera and some additional eastern Australian species to be found later in the south-west had also been named, primarily by Robert Brown (1810).

Early colonial phase

The arrival of James Drummond (1784–1863) at the Swan River with Captain Stirling's colonizing party on the Parmelia in 1829 heralded a major advance in knowledge of the south-west's orchids (Erickson 1969). Drummond, a Scot and keen nurseryman, formerly Curator of the Botanical Gardens at Cork, Ireland, was designated as unpaid Government Naturalist for the Swan River Colony.

Drummond soon became occupied as the Colony's official gardener, and was paid as such for a year (1831–1832). Additionally, he established homes and farms for his family briefly at Guildford (November 1829), but then at Ascot (early 1830), at the foot of Mt Eliza (1831), at Helena Valley (1831), and finally the main farm *Hawthornden* at Toodyay (1836).

In these early years, the family came to know the plants and animals of the Perth area intimately. As Rica Erickson (1969) recounted:

> "Their adopted land enchanted the Drummond family. Each member brought home new plants which they found in the bushland. At the time there were few books written on the flora of Australia. Those in their possession were pored over by Drummond as he sought to identify flowers, many of which had never been seen before. The boys were most successful collectors, as they spent much time in the bush and had many opportunities when they went hunting and shepherding, or searching for lost stock.
>
> Plants were not their sole interest. They built up a large collection of insects, and they learned to skin birds and other animals for scientific collectors at Capetown. It is known that they sent at least two extensive collections to South Africa where such specimens and seeds of wildflowers found a ready sale with recognized agents there. The shelves in their home were always overflowing with specimens."

A visitor to the Swan River Colony in 1831 was to initiate a chain of events of long-lasting significance to the collection and botanical description of the local flora, especially the orchids. Captain James Mangles, retired naval commander, arrived aboard the *Atwick* in April for a three month stay at the invitation of his cousin, Lady Stirling, the Governor's wife.

Mangles, of London, was noted for his authorship of "Travels in Egypt, Nubia, Syria and Asia Minor in 1817–18", and was a man of sufficient wealth, interest in the sciences and public spirit to be a Fellow of the Royal Society, Fellow of the Royal Geographical Society, and active member of the Ornithological Society and Horticultural Society. With regard to plants, he promoted the growing of species from foreign countries in gardens throughout Britain.

Mangles met many of the Swan River colonists during his stay, and struck up a friendship with George Fletcher Moore, Commissioner of the Civil Court (Moore 1884). The occurrence of Mangles' visit in late autumn to early winter meant that he missed the main wildflower season. However, Moore gave Mangles "some specimens of flowering shrubs, besides a bottle full of snakes, lizards and scorpions" as a gift of Swan River collections. These, together with others taken back to England by Mangles, aroused considerable interest in the exotic flora of south-western Australia.

In the meantime, another distinguished patron of botany and noted traveller, Baron Karl A.A.F. von Huegel of Vienna, visited the Swan River Colony and King George Sound from 17 November 1833 to 12 January 1834. Huegel collected many specimens during his brief visit, which was described by Diels (1906) as follows:

> "He investigated the islands at the entrance to the Swan River, collected on both banks in the neighbourhood of Perth, and penetrated towards the interior as far as the foot of the Darling Range, at Darlington. He remained on the Swan River until the 19 December, and then continued on by sea to King George Sound where he remained from 1–12 Jan. 1834. His excursions were made in the immediate vicinity of the Sound but also not far from Albany and then on to the King and Kalgan Rivers – naturally on the lower courses of these rivers."

Three orchids were subsequently named from reputed Huegel collections – *Elythranthera brunonis* (Endl.) A.S. George (as *Glossodia brunonis*, by Endlicher 1839), *Thelymitra flexuosa* Endl. (Endlicher 1839) and *Caladenia huegelii* H.G. Reichb. (Reichenbach 1871). The type sheet of the latter species actually has three species on it - typical *C. huegelii* (as lectotypified by Hopper and M. Clements in Clements (1989), not by George (1971a)), *C. paludosa* Hopper & A.P. Br. and *C. ensata* Nicholls (not *C. longiclavata* E. Coleman var. *longiclavata* as stated by George 1971a). Only two of these five species (*E. brunonis* and *C. paludosa*) have been collected or recorded flowering as late as late November. Hence, it seems highly improbable that Huegel collected any of these orchids himself. It is likely, in fact, that the Drummond family may well have given dried specimens of some or all of these species to Huegel, given their enthusiasm recounted above for the local flora of the Swan River. Huegel and James Drummond knew each other well enough for Huegel to be included among the subscribers to Drummond's future collections of seeds in the early 1840s.

In July 1835, George Moore and Lady Stirling received letters from Captain Mangles seeking assistance in obtaining seeds and live plants from Western Australia. Moore was aware that James Drummond and his son Johnston, then resident in the Helena Valley, were collecting seeds of native plants for shipment and sale at Capetown. Moore purchased 100 packets of seeds from the Drummonds and shipped them immediately back to Mangles. Late in 1835 an enthusiastic reply was received requesting more material.

In the meantime, on September 18, James Drummond independently wrote to Mangles offering to collect seeds and specimens for payment. A sample of seeds of several species was included with Drummond's letter. Mangles forwarded the letter on to Dr John Lindley, Professor of Botany of London University, Secretary of the Horticultural Society, and renowned orchidologist, who wrote back to Mangles in December 1836 in favour of the idea:

> "I think good Swan River specimens would sell for two pounds per 100 papers, that is the market price for such things. Probably a dozen purchasers at least would be found. But as it is not known how Drummond would prepare the specimens I recommend him to send 2 or 3 sets of 100 or 150 each upon trial. I will take one set. We horticultural people wish for ten pound worth of seeds and bulbs as a venture. Nothing but very handsome things will do, we would rather have a good deal of seed of a very few sorts than a little seed of a good many sorts. If the seed suit us, we may be very good customers."

Mangles responded immediately to Drummond's letter of September 1835 requesting, among other things, all kinds of orchids. Thus began Drummond's career as a major commercial collector of south-western flora, with an initial focus on orchids.

In 1836 he prepared a box of orchid tuberoids for shipment. They perished on the voyage to London, as he suspected they would, and insects consumed all the seeds sent as well. Undeterred, Drummond wrote again on 23 August 1836 offering his services as a collector:

> "If you can procure me some orders to enable me to live in the bush I will send you specimens and seeds, mosses and insects etc. until you are tired of them"

It would be a year later in September 1837 before Drummond received letters of support from both Mangles and Lindley. At this stage, he was given no idea that Mangles was losing interest in his commercial collecting activity.

This was reflected by the fact that Mangles also wrote in December 1836 to colonists recommended by Lady Stirling who might collect seeds for sheer interest rather than as a source of income. Included among these were Mrs Georgiana Molloy of Augusta and Captain Richard Meares of Guildford, both of whom agreed to help.

Mrs Molloy, a keen gardener, and her young family took on the task with enthusiasm through the spring of 1837 (Hasluck 1955). Specimens were pressed and numbered as each species flowered, and plants watched thereafter (especially by daughters Sabina and Mary) for the fruits to ripen ready for collection of seed.

Tragically, her infant son John was drowned in November of that year. Overcoming this event, a subsequent sickness and pregnancy, together with the demands of running an isolated colonial household, delayed preparation for shipment of Mrs Molloy's meticulously pressed specimens for another year. The delay enabled additional specimens from the spring of 1838 to be added, including plants collected by Captain Molloy from The Vasse (Busselton). On November 16 of that year, Mrs Molloy shipped her specimens and seeds to Lady Stirling for subsequent shipment to Mangles in London.

In the meantime, James Drummond also spent the spring of 1837 collecting material for shipment to Mangles in November 1837 on the *Hero*. The box contained 'some hundreds of the most beautiful plants', including 'about 200 tubers of native orchids'. Mangles had also sent old newspapers, and this enabled Drummond to press and dry specimens of many plants collected on the Swan Coastal Plain, along the Toodyay Road and in the vicinity of Toodyay. Orchids were included in this collection.

Fulfilling this order led Drummond, on 18 October 1837, to finish writing the first account of the underground structures of Western Australian orchids. The paper was published in the *Gardener's Magazine, London*, the next year (Drummond 1838). This paper is remarkable in its modern appreciation of the biology and taxonomy of the orchids found in and near Perth.

For example, Drummond accurately described and depicted the fibrous multilayered tunica that ensheaths the tuberoids of species of *Cyanicula* Hopper & A.P. Br. and *Elythranthera* A.S. George. Furthermore, he was of the view that such species "belong to two genera", that were quite distinct from *Caladenia*. In this paper, he also made clear the differences in leaf morphology between *Drakaea livida* J. Drumm. and *D. elastica* Lindl., and described as separate species *Caladenia longicauda* Lindley and *C. huegelii* in unmistakable terms:

> "The large species I send you ... has sometimes a flower 11 in. from tip to tip of the petals; and another species, with a yellow flower and dark purple lower lip, grows nearly as large, and is a very beautiful plant."

Drummond had a disagreement with Lady Stirling about to whom had been intended boxes of plants and trees sent by Mangles aboard the *Hero*. This disagreement was conveyed to Mangles by Lady Stirling, and may have led to further consideration by Mangles' to cease facilitating Drummond's collecting activities.

However, on receiving Drummond's first collection of dried specimens on the return ship early in 1838, Mangles handed them on to Dr Lindley, who was delighted to find many new species and genera among them. Lindley prepared descriptions of some of these for publication. The collection affirmed Drummond's importance as a collector among English botanists.

In September 1838, George Fletcher Moore was advised in a letter from Mangles that the latter wished to terminate his seed orders. Drummond was not so advised until after the departure for England of the *Joshua Carroll* on 8 December 1838. On board was a major consignment of seeds, live plants and dried specimens, consigned by Drummond at his own cost to Mangles. Also, Lady Stirling forwarded Georgiana Molloy's collections on the same boat.

Drummond, perplexed by the change of interest of Mangles, was powerless to recall or redirect his shipment. After arriving at Mangles' door early in 1839, it ended up in the hands of Dr Lindley, who secured the volunteer services of a young George Bentham to divide the collection up and distribute it.

Lindley was pleased to receive the new material from Drummond and Mrs Molloy, as he had yet to finalise his manuscript describing plants from the Swan River Colony, and several more new taxa were among those presented to him. Drummond was not to know the fate of these specimens for some time yet.

Meanwhile, in a letter dated 28 May 1839 to Hooker, Drummond indicated that he had decided to make another substantial collection (ten sets of 1000 species) the coming spring, in the hope that subscribers could be found. He indicated in the letter that he had already gathered some 60 species of Orchidaceae, and that "a zealous young German botanist – a Mr Preiss, had lately arrived here".

Johann August Ludwig Preiss (1811–1883), was the only notable European collector of orchids in the early colonial phase. His south-western Australian specimens were labelled with locality information and the date of collection, enabling some of his movements to be traced with considerable accuracy (Marchant 1990). Preiss's orchid collections were written up by Endlicher (1846) in a multi-authored two-volume work "Plantae Preissianae" edited by Professor Lehmann of Hamburg. By the time this work was published, most of the species collected by Preiss had already been described by Lindley (1840) from Drummond's collections.

The earliest orchid collection of Preiss cited in this work is of *Caladenia unguiculata* [= *Cyanicula deformis*] obtained on 19 January 1839 from woodland near the Limekiln (vicinity of Subiaco), Perth. Preiss subsequently made orchid collections in June at Lake Monger, July at the Canning River, Guildford and Darling Scarp cataracts on Susannah Brook, and August on Rottnest Island before venturing eastwards to York in late August to early September. On returning to Perth, on 23 September 1839, Preiss collected the type of *Elythranthera brunonis* in woodland on sand. He made a few more orchid collections near to Perth in the ensuing months before venturing to Albany, where his first orchid collection was of *Cryptostylis ovata* from Strawberry Hill on 9 January 1840.

Later in 1840, Preiss collected orchids from Albany and the granite inselberg Willyung nearby to the north. The most important of these specimens was the type of *Caladenia nana*, collected from Mt Clarence on 5 October 1840. Back in Perth in 1841, Preiss made a couple of orchid collections from the Darling Range, including a small variant of *Caladenia longicauda* Lindley which Endlicher recognized as forma *humilior* (possibly *C. longicauda* subsp. *clivicola* Hopper & A.P.Br.). This was an important early insight from a European taxonomist that there was actually infraspecific variation in a species of south-west Australian orchid which many subsequent authors would subsume in unworkably broad concepts of polymorphic Australian orchid species.

In June 1839, Drummond wrote a long letter describing the plants to be seen between Fremantle and Perth. The letter was published in 1840 in Hooker's Journal. Drummond indicated that between

the Swan River and the top of the Darling Range, he had collected 30 species of Orchidaceae. He described a selection, including what were subsequently named as *Epiblema grandiflora* R. Br., *Paracaleana nigrita* (J. Drumm. ex Lindl.) Blaxall, *Drakaea livida* J. Drumm., *D. elastica* Lindl., and *Spiculaea ciliata* Lindl.

Subsequently, from his farm at Toodyay on 14 October 1839, Drummond penned another letter to Hooker detailing discoveries made during his busiest spring yet. After describing plants encountered on a visit to Rottnest Island in company with the botanist Preiss, the bird-collector John Gilbert, and a Dr Walker, Drummond recounted observations of orchids seen between Perth and Toodyay. Firstly, he wrote of *Cyanicula* Hopper & A.P. Br:

> "A pretty Orchis which I cannot refer to any of Mr Brown's genera is now in blossom by the roadside; it is remarkable for producing varieties of blue, yellow and white flowers. I am acquainted with two other species of the same genus, with blue flowers varying to white, but this is the only instance I can recollect of a blue flower changing into a yellow; the yellow kind is very rare to the west of the Darling Range of hills where the blue is common; but in the Toodjey district some of the hills produce the yellow plant in thousands without any mixture of blue; still I am satisfied they are the same species."

Drummond was here describing the blue *C. gemmata* (Lindl.) Hopper & A.P. Br. and the yellow *C. ixioides* (Lindl.) Hopper & A.P. Br., which we consider to be distinct species. The other two cyaniculas he alluded to were undoubtedly *C. deformis* (R. Br.) Hopper & A.P. Br. and *C. sericea* (Lindl.) Hopper & A.P. Br., both common in the country by then well known to him. He continued:

> "My family have paid a good deal of attention to the Orchideae and we have gathered between 60 and 70 species; the few botanical books I brought out with me having been soon lost by a fire, we consequently know nothing of the names of even the genera, but every Orchis we found for the first time was new to us and were distinguished among the different members of the family, by the finders name, such as Jane's yellow spiral leaved, John's spotted spiral leaved, etc. etc.
>
> My youngest daughter, Euphemia, knows the Swan River Orchideae quite as well as I do myself and she is able to tell any of her brothers who pick up an Orchis, whether there is any chance of its being what we call a new one or not. Some of the genera, for we found it necessary to make genera to help in distinguishing the different species, turned out to be exactly the same as Mr Brown's."

Drummond then went on to describe how rare some of the orchids were, and detailed three species of interest seen for the first time that season – *Caladenia falcata* (Nicholls) M.A. Clem. & Hopper, a greenhood he named *Pterostylis rupestris* J. Drumm., and *Caladenia barbarossa* H.G. Reichb. Of the latter, Drummond remarked:

> "A third Orchis, also detected this season, forms a different genus from any we had seen before; its lower lip resembles an insect and assumes the appearance of a head and feet, which none of the other insect-like Orchideae have."

Thus, Drummond and his family had acquired an impressive understanding of the orchids between Fremantle and Toodyay, recognizing 60–70 species, and distinguishing what we have named

Cyanicula and *Caladenia* subg. *Drakonorchis* Hopper & A.P. Br. (Hopper & Brown 2000) as distinct genera from *Caladenia*. By the end of the 1839 spring, however, Drummond had ceased corresponding with Mangles, and was to lose interest in making further substantial collections of orchids.

Understandably, there must have been a mixture of pleasure and consternation when Drummond finally received a copy of Lindley's "A Sketch of the Vegetation of the Swan River Colony", which was published early in 1840 and drew heavily on Drummond's letters and his paper on the underground structures of Swan River orchids.

Lindley, working with dried specimens and without the insights of seeing living plants, described some 50 species, not 60–70. He also did not recognize *Cyanicula* and *Caladenia* subg. *Drakonorchis* as genera distinct from *Caladenia*. He did, however, recognize most of what Drummond sent him as distinct, and this must have pleased Drummond.

Nevertheless, in a letter to Hooker dated 13 April 1842, Drummond expressed concern at how Lindley had lumped species of kangaroo paw (*Anigozanthos*) and *Drakaea* Lindley that to him were perfectly distinct and good species when seen as living plants (see opening quotation). In the same letter he described a specimen of *Calochilus* R. Br. found near Toodyay, "the only individual I have ever found of a most curious orchideous plant".

Drummond's waning interest in orchids was evident, but he did make one further interesting discovery in the spring of 1844 while travelling north of Toodyay to the vicinity of Lake Moore. In a brief sentence, he unmistakably describes his discovery of *Caladenia drakeoides* Hopper & A.P. Br.

> "Near our first bivouac I gathered a singular Orchidaceous plant having the hinged lower lip of *Drakea* but with other characters which will probably refer it to the same genus with 861 of my large collection: only three plants could be detected in flower and one of them I put into spirits as you directed. Our present mode of travelling is not favourable for collecting Orchidaceae which require close investigation of particular spots in order to detect them ..."

Drummond's collection number 861 is the type specimen of *Caladenia barbarossa* H.G. Reichb., gathered near Toodyay in 1839.

Taxonomic concepts

Our taxonomic concepts are described below. Few authors have provided such information in previous publications dealing with Australian orchids. Fitzgerald (1888) was a notable exception (see his discussion of *Caladenia dilatata* and *C. patersonii*). More recently, Clements (1989) provided a brief account of his concepts of taxonomic rank.

An explicit statement of concepts is essential for the scientific evaluation of a taxonomic work. Without it, future readers are unable to understand accurately the hypotheses underlying the names provided, and critical testing of such hypotheses is rendered difficult. While we accept that an element of subjectivity is part of all scientific inquiry, the best works in the field are those that present ideas and data in a way that ensures that they can be examined critically and tested by other workers.

Species and subspecies

New species are recognized if they grow in populations (i.e. are not aberrant individuals within normal populations), if they have features or a combination of features not seen in any previously named species, and especially if they grow with previously named species and produce few or no natural hybrids. Differences in flowering times, in habitats occupied, and in pollinators are other attributes we have used to help identify new species in some cases. Geographical races with minor morphological differences are recognized as subspecies. These may hybridize and intergrade extensively where their geographical ranges overlap. Our species and subspecies concepts are thus both morphological and biological, springing from the approaches lucidly summarised by Grant (1981).

It is important to note that our consideration of biological as well as morphological data in deciding on species rank is a fundamental difference to the approach of George (1971a) and his predecessors. It leads to the recognition of more species. In allocating species rank, George took little account of breeding barriers between coexisting taxa. For example, many combinations of the five varieties of *Caladenia filamentosa* R. Br. recognized by George (1971a) grow together without hybridizing, but he judged them to be only worthy of varietal rank. In contrast, because of their predominant failure to interbreed when sympatric, we recognize these five taxa and a number of others previously undescribed as species.

Hence, our approach in some cases leads to a morphologically narrower species concept than those advocated by George (1971a) and others. However, we have ensured that all taxa recognized as species have reliable diagnostic morphological characters. To take the *Caladenia filamentosa* complex as an example, George's broad concept of the species in Western Australia emphasised as diagnostic features the long filiform non-clavate petals and sepals, the calli in two rows, and the short marginal teeth on the labellum. To identify species of the *C. filamentosa* complex in our treatment, users are required to look closer and examine attributes such as the shape, size, three dimensional structure and colour of flower parts and leaves. We have found that many local orchid enthusiasts become adept at recognising such distinctions once they have been pointed out. Hence, we are encouraged that our narrower species concepts are nevertheless workable.

We believe that they have the additional advantage of more closely reflecting biological reality than do the broad concepts of "polymorphic" species of past authors. There are many practical advantages arising from our treatment, not the least being improved management for conservation and cultivation, and more precise communication and conduct of popular and scientific studies of south-western orchids.

For example, a broad concept of *Caladenia filamentosa* includes populations of diverse ecological tolerances and phenologies, from winter flowering plants on remote granite outcrops well inland in the arid pastoral region, to early summer flowering plants in the highest rainfall country on consolidated dunes of the south coast. Knowing that *C. filamentosa sens. lat.* is on a conservation reserve provides little practical help to a manager concerned about fire regimes, for instance, because the literature would indicate that the flowering season could be any time over a six month period, and the habitat occupied could be anything from well-drained soils on the highest eminences, to seasonally-waterlogged flats low in the landscape. Similarly, the appropriate watering regime for cultivated plants is difficult to predict if all the grower knows is that specimens are of *C. filamentosa* in the broad sense. Both the conservation manager and the grower are forced to find out for themselves exactly what are the biological attributes of the particular plants of *C. filamentosa* that they are looking after (often to the detriment of the orchids if initial guesses about fire or watering regimes are wrong).

The poor predicability of such a broad species concept contrasts with that in our treatment of the *Caladenia filamentosa* complex. Land managers or orchid growers will know, for example, if they have plants of *C. abbreviata* Hopper & A.P. Br., that they are late-flowering denizens of south-coastal dune country requiring good soil moisture conditions. *C. remota* Hopper & A.P. Br. is a winter/spring flowering inhabitant of inland arid zone granite rocks subjected to prolonged periods of dry soil. *C. dimidia* Hopper & A.P. Br. occurs in the wheatbelt on good soils, etc.

To highlight another significant implication of the species concept adopted, a broad view of *Caladenia filamentosa* gives no suggestion of conservation problems, because members of the complex range all across southern Australia, and some are abundant in conservation reserves. Even if rare infraspecific taxa are recognized such as George's (1971a) concept of *C. filamentosa* var. *dorrienii* (Domin) A.S. George, they will not feature in the national list of rare and threatened plants (Leigh & Briggs 1996) because it includes only species.

In contrast, our treatment segregates out from the *Caladenia filamentosa* R. Br. complex several common well-reserved species but also a few that are rare, such as *C. dorrienii* Domin and *C. elegans* Hopper & A.P. Br. (Hopper *et al.* 1990; Brown *et al.* 1998). If our concepts are followed, these threatened plants will receive the attention they deserve from authors such as Green (1985) and Leigh & Briggs (1996) who ignore infraspecific taxa.

Of course, we do not advocate the elevation of all infraspecific taxa to specific rank for this reason. Such an approach leads to unacceptably narrow species and an often unworkable taxonomy (see below). But where taxa meet our biological criteria regarding strong reproductive isolation in sympatry, and are morphologically distinct, species rank is considered most appropriate.

Perhaps the legacy of greatest concern regarding past concepts of polymorphic Australian orchid species is the diminished value of much of the information in the popular and scientific literature. Almost without exception, previous authors, despite making meticulous observations over considerable periods, have used names like *Caladenia filamentosa* or *C. patersonii* without citing voucher specimens nor even giving precise locations from where their material came.

This serious oversight recurs in popular books and field guides (e.g. Pelloe 1930; Blackall & Grieve 1954; Erickson 1965; Nicholls 1969; George & Foote (undated); Cady & Rotherham 1970; Clyne 1970; Pocock 1972; Hoffman & Brown 1984; Woolcock & Woolcock 1984; Jones 1988; Bennett 1988; Bates & Weber 1990). Perhaps even more unexpectedly, voucher specimens are rarely cited in scientific studies of south-western orchids dealing with mycorrhizal fungi (Warcup 1971; Ramsay *et al.* 1986), pollinators (Sargent 1907; Stoutamire 1974, 1975, 1981, 1983; Bates 1979; Peakall 1984, 1988, 1989; Peakall & James 1989b), chromosome numbers (Peakall & James1989a), or hybrids (Hopper 1973, 1979; Heberle 1982).

Without voucher specimens, it is often difficult or impossible to relate much valuable and expensively-acquired data to the species segregated out from species complexes by previous taxonomists or ourselves. Conflicting results obtained by researchers working on the same topic may be due to the fact that they are working on different species within a complex. One only has to read the various attempts of authors to describe broadly-conceived species such as *Caladenia filamentosa sens. lat.* to appreciate this problem.

In many ways, the development of concepts regarding these orchid species complexes parallel that described by Hillis *et al.* (1983) for the American Leopard Frogs (the *Rana pipiens* complex). These

animals were the standard tool for generations of zoological physiologists. Numerous scientific papers were written about these animals, often with conflicting results and acrimonious assertions. Although 12 species had been described in the complex from conventional morphological studies by 1900, the number was reduced to four as the polytypic species concept rose to ascendancy among vertebrate zoologists in the 1940s and 1950s. However, intensive field work in the 1960s and 1970s established that there were, in fact, many taxa that occurred in sympatry with little or no hybridisation. These taxa had distinctive morphological, auditory, biochemical and reproductive attributes, leading to the realisation that there were indeed numerous distinct species of leopard frogs (23 are now recognized). Much of the conflicting results of earlier work was accountable by opposing researchers using different species for their experiments, but reporting that they were using the same (polytypic) species.

The situations detailed above for species concepts in the *Caladenia filamentosa* R. Br. complex could be repeated for several other complexes in south-western Australia. As with the final resolution of the leopard frog complex, we consider that our taxonomic concepts for these orchids have significant practical implications that will considerably advance the cultivation, conservation and study of the plants involved.

Because of the past use of varieties for many taxa now recognized as species, we have avoided using the rank of variety for infraspecific taxa, and instead use subspecies as the appropriate category. Interestingly, Clements (1989) and Jones (1991, 1998) recognized very few infraspecific taxa in their treatments of Australian orchids, favouring species as the preferred lowest rank. This approach is too constraining in our view, and may create unnecessary problems for users of their taxonomy by advocating very narrow species concepts in some cases.

For example, Clements (1989) regarded *Caladenia longicauda* Lindl. and *C. eminens* (Domin) M. Clem. & D.L. Jones as distinct species. Our studies show that these taxa are very similar morphologically, and intergrade where their ranges overlap. In many populations, we have not been sure if they comprise *C. longicauda* or *C. eminens* or both, even with fresh flowers in the hand. In other populations removed from the zone of overlap, the taxa can be recognized with greater certainty. It seems more appropriate, in such circumstances, to regard these taxa as subspecies rather than as species. Similar considerations underlie our conviction that *C. nana* Endl. and *C. unita* R. Fitzg. are best treated as subspecies rather than species as advocated by Clements (1989).

Further resolution of species in Australian orchids is just emerging from genetic studies using allozyme and DNA markers. For example, Carstairs & Coates (1994) examined allozyme variation among populations within rare south-western taxa of *Caladenia, Drakaea, Diuris* and *Rhizanthella*. Recognized species behaved as expected in these genetic analyses. Carstairs (pers comm.) examined relationships within selected south-western *Caladenia* using allozyme markers, and established the genetic distinctness of groups represented by *C. hirta* Lindl., *C. falcata* (Nicholls) M.A. Clem. & Hopper, *C. longicauda* and *C. caesarea* (Domin) M.A. Clem. & Hopper. He also established that some closely-related species recognized by us, such as *C. caesarea* and *C. luteola* Hopper & A.P. Br., were genetically distinct.

More recently, Kores *et al.* (2000) have examined DNA sequence data, especially for the *Caladenia* alliance, and have obtained some additional evidence of species relationships (cf. Hopper & Brown 2000). Further work is needed in this exciting field to test hypotheses of species boundaries erected in this series of papers.

Hybrids

Some south-western orchid hybrids are spectacular, readily identified and often encountered. Others are rare, and warrant special protection. Many found by orchid enthusiasts cause considerable identification problems because, hitherto, they have largely been ignored in published works on Western Australian orchids (other than by Hopper 1979; Heberle 1982).

For these reasons, hybrids are recognized and named formally by us if they occur as sporadic individuals among mixed populations of likely parental taxa, and where their flowers are clearly intermediate between those of their presumed parents. The presence of an "x" preceding a species' name denotes its presumed hybrid status.

We have not formally named hybrids where their identification is rendered difficult by the presence of backcrosses in many populations, so that a complete transition in form occurs from one species to the other. In such situations, reference to hybrids is preferred by the conventional formula of the names of the parental taxa linked by an "x".

Genera

Since the early 1980s, we have been examining generic relationships in Australian orchids. Initially, new genera were recognized on the basis of detailed numerical taxonomic studies of Australasian and South American terrestrial genera (Hopper, unpubl. ms). This work established the presence of some segregate genera within *Caladenia sens lat.*, and also identified the generic distinctness of what is now known as *Pyrorchis* D.L. Jones & M.A. Clements from typical *Lyperanthus*.

We informally published our conclusions on generic matters in colour field guides to enable wide scrutiny of our concepts before formal publication (Hoffman & Brown 1992, 1998). We argued for a reduced circumscription of *Caladenia*, with the reinstatement of *Leptoceras* (R. Br.) Lindley and the erection of three new genera, *Cyanicula, Praecoxanthus* Hopper & A.P. Br. and *Drakonorchis*. We also proposed that *Lyperanthus nigricans* R. Br. and *L. forrestii* F. Muell. be transferred to the genus *Burnettia* Lindl., but subsequently (in ms.) proposed to erect a new genus. This latter conclusion was supported and overtaken by Jones & Clements' (1994) description of *Pyrorchis*.

Recent DNA sequence studies of the Orchidaceae, including the Diurideae and the *Caladenia* alliance in particular (Kores *et al.* 2000, 2001), have affirmed our proposals except for *Drakonorchis* which appears to be deeply embedded within *Caladenia* (Figure 2). Elsewhere (Hopper & Brown 2000) we formally described *Cyanicula* and *Praecoxanthus*, and presented a new subgeneric classification of *Caladenia* R. Br. in which five subgenera were recognized, three previously regarded as sections of the genus by Bentham (1873) and two newly named as *C.* subg. *Drakonorchis* Hopper & A.P. Br. and *C.* subg. *Elevatae* Hopper & A.P. Br. A key to all genera currently recognized in south-western Australia is given below.

Key to genera of south-west Australian orchidaceae

1. Subterranean herbs, saprophytic. Inflorescence a many-flowered capitulum ..... **Rhizanthella**
1: Terrestrial herbs with leaves and flowers above ground, rarely saprophytic. Inflorescence a raceme

2. Plant with rhizomes. Flowers bell-shaped ..... **Gastrodia**

2: Plant with root-stem tuberoids. Flowers not bell-shaped

3. Leaves perennial, arising from tuberoid adjacent to flowering scape; petiole 2–10 cm long ..... **Cryptostylis**

3: Leaves replaced annually, subtending the scape; petiole absent (except *Eriochilus*)

4. Column usually longer than 5 mm tall, lacking free staminodia; viscidium absent or reduced

5. Petals and dorsal sepal united to form a hood enclosing column. Auricles on column wings abutting in front of anther. Stigma more than twice length of anther ..... **Pterostylis**

5: Petals and dorsal sepal free. Auricles (if present) on column wings not abutting. Stigma *c.* same length as anther

6. Labellum claw c. same length as lamina, closely appressed to column. Pollinia divaricated, almost contracted into caudicles ..... **Eriochilus**

6: Labellum claw usually much shorter than lamina, if same length then not closely appressed to column. Pollinia simple, not contracted

7. Leaves solitary, hirsute, usually linear

8. Tuberoids encased in a multilayered tunica; hairs lacking enlarged basal cell; flowers usually blue, purple or pink

9. Upper surface of petals and sepals glossy. Calli 2, enlarged, basal ..... **Elythranthera**

9: Upper surface of petals and sepals dull. Calli numerous along lamina

10. Petals and sepals blue (rarely yellow or white). Calli numerous, gradually decreasing in size from the base of the lamina apically ..... **Cyanicula**

10: Petals and sepals pinkish purple. Calli in *c.* 12 pairs, the basal pair thickly cylindrical and much larger than the rest ..... **X Cyanthera**

8: Tuberoids partially encased in a few layered tunica; hairs with an enlarged basal cell; flowers usually other than above (sometimes pink) .. **Caladenia**

7: Leaves solitary to several, glabrous, usually ovate to oblong

11. Labellum insectiform; claw c. same length as lamina

12. Scapes wiry, with 1(2) flowers (except *P. lyonsii* 2–10 flowers)

13. Labellum claw hinged and passively mobile. Column curving upwards and with narrow auricular wings not pouched ..... **Drakaea**

13: Labellum claw not hinged, actively sprung on touch. Column obliquely descending and with much-enlarged wings forming a pouch ..... **Paracaleana**

12: Scapes fleshy, with 4 or more flowers ..... **Spiculaea**

11: Labellum not insectiform, claw much shorter than lamina

14. Petals erect, clavate, usually glandular

15. Leaves green with red stripes. Labellum transversely oval, lacking calli, margins fimbriate ..... **Leporella**

15: Leaves green. Labellum trilobed, calli numerous, margins entire ..... **Leptoceras**

14: Petals horizontal to downcurved, not clavate nor glandular

16. Dorsal sepal hooded over column
17. Flowers sessile, solitary ..... **Corybas**
17: Flowers borne on a scape, few to many
18. Leaf fleshy, ovate. Labellum lamina with prominent fleshy longitudinal ridges and sparse small hemispherical calli ..... **Pyrorchis**
18: Leaf thin, linear. Labellum lamina lacking ridges and calli densely clustered, incudiform, pyramidal, cylindrical to irregularly oblong and serrate on top or hemispherical ..... **Lyperanthus**
16: Dorsal sepal held erect splaying away from column
19. Scape subtended by a fully developed basal leaf, many-flowered. Labellum glabrous ..... **Cyrtostylis**
19: Scape subtended by a reduced bract-like basal leaf, 1-flowered. Labellum with calli ..... **Praecoxanthus**

4: Column absent or shorter than 5 mm, with prominent free or united (mitral) staminodia; viscidium present
20. Leaves terete or tubular
21. Labellum on lower side of flower, below dorsal sepal ..... **Microtis**
21: Labellum on upper side of flower, above dorsal sepal
22. Leaf well developed beyond point of departure from scape. Labellum immobile. Column with no basal foot. Anther held vertically and attached dorsally at the base, with a poorly developed rostrum ..... **Prasophyllum**
22: Leaf reduced and bract-like beyond point of departure from scape. Labellum highly mobile. Column with a prominent curved basal foot. Anther held obliquely erect or horizontal and attached dorsally at the apex, with a strongly developed rostrum ..... **Genoplesium**
20: Leaves channelled, distichous or flat
23. Leaves 2 to many. Labellum prominently trilobed. Anther and stigma sessile on ovary roof; staminodia free, not cucullate ..... **Diuris**
23: Leaf solitary. Labellum not prominently trilobed. Anther and stigma on a short column; staminodia united into a cucullate mitra or free
24. Labellum petal-like, lacking appendages ..... **Thelymitra**
24: Labellum clawed, with basal calli or densely hirsute
25. Labellum same size as petals and sepals, glabrous except for basal calli ..... **Epiblema**
25: Labellum longer than petals and sepals, densely hirsute ..... **Calochilus**

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